

# Magnets & Beam Pipe (WBS 1.1) and Detector Installation, Integration and Commissioning (WBS 1.10)

Chuck Brown (WBS 1.1)

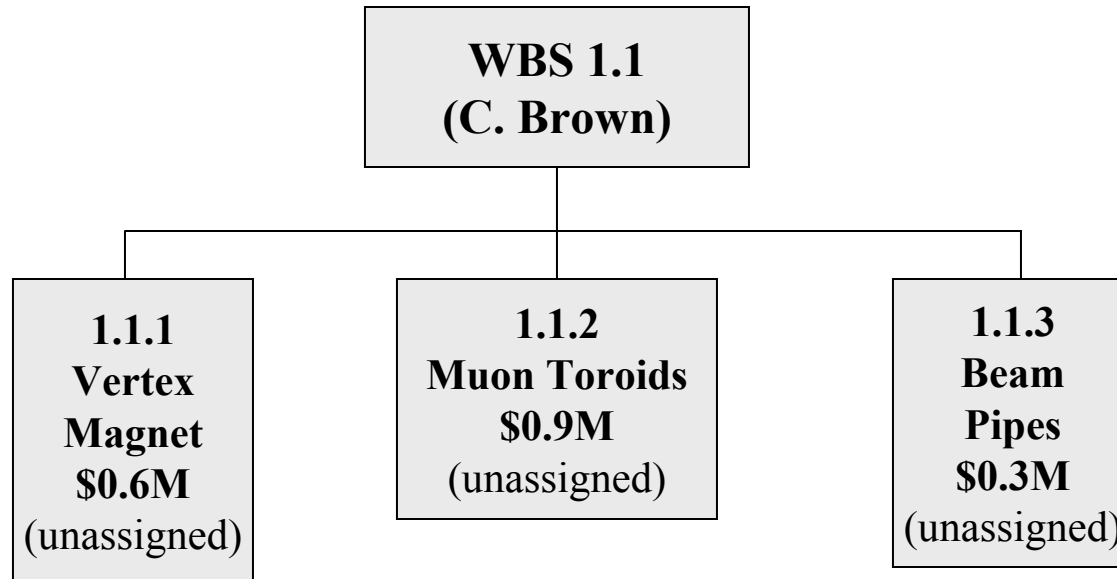
Joe Howell (WBS 1.10)

- Introduction and overview of the BTeV magnets and beam pipe and detector installation, integration and commissioning
- **WBS 1.1** – Vertex magnet, Toroid Magnets & Beam Pipe
  - Project management overview
  - Description of major components
  - Cost and schedule information
- **WBS 1.10** – Detector Installation, Integration and Commissioning
  - Project management overview
  - Installation setting
  - Detector characteristics
  - Cost and schedule information
- Presentations prepared for the breakout sessions

- The purpose of the Vertex Magnet is to provide a strong uniform magnetic field in the region of the silicon pixel detector in order to allow the momentum of high-energy particles to be determined at the trigger level and to provide a large integrated magnetic field to provide excellent mass resolution for multi-body decays of B hadrons when the pixel detector and forward tracker are used together to determine track momentum.
- The purpose of the North instrumented Toroid Magnet is to provide a magnetized iron absorber that will absorb all hadrons emitted from the interaction region and hence will identify muons (since a muon is the only charged particle that can penetrate 2 meters of iron) and, by deflecting the muons magnetically, help confirm their momentum for purposes of triggering the data acquisition system.
- The purpose of the South un-instrumented Toroid Magnet is to provide shielding and magnetic symmetry.
- The purpose of the Beam pipe is to provide the high vacuum containment for the accelerator beams through the BTeV apparatus.

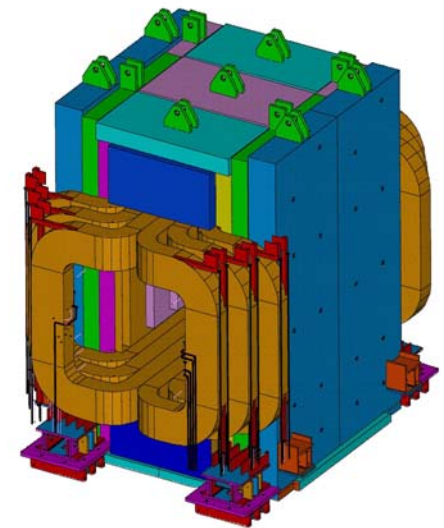
- Vertex magnet – 1.6 T vertical bend dipole magnet at detector interaction point
- North Toroid pair (~1 m each) with compensating dipole, 10 cm filter plate and installation features for Muon chambers
- South Toroid pair (same as above except no filter plate or Muon chamber features)
- Forward tracking beam pipe with aluminum window and 2.5 cm diameter beryllium beam pipe section
- 5 cm diameter beryllium beam pipe through RICH detector
- (Conventional stainless beam pipe sections as needed)

Base cost: \$1.8M (M+S: \$1.3M, Labor: \$0.5M)



These are fairly conventional tasks at Fermilab

- Characteristics
  - Disassembly and rebuild of SM3 (E-605)
  - New pole inserts
  - New features for rolling into collision hall
- Cost Summary
  - Total → 581K\$ construction + 148k\$ cont. (25%)
  - 45K\$ - Design
  - 368K\$ - Procurement (disassembly + transport)
  - 167K\$ - reassembly + testing
- Schedule Summary
  - Forward loaded for early installation
  - Ready for installation 2006
  - Critical Path: new pole insert iron, assembly hall availability



## ■ Characteristics

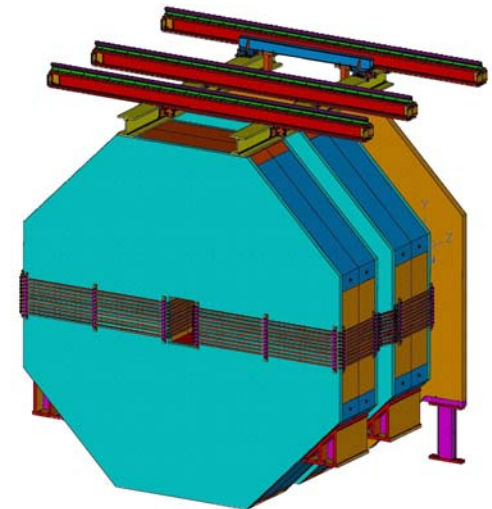
- Recover and rework SM12 Iron
- New coils on both pairs of Toroids
- Muon support features on North Toroid only
- Features for rolling into collision hall and support
- Mounts for compensating dipoles

## ■ Cost Summary

- Total → 831K\$ const. + 232K\$ cont. (28%)
- 47K\$ - design    560K\$ - procurement
- 224K\$ - assemble & test

## ■ Schedule Summary

- Forward loaded for early installation
- 1st Toroid pair ready for installation 2006
- 2nd Toroid pair ready for installation 2007
- Critical Path: additional iron, new coil



## Characteristics

- Reworked CDF run 2b Beryllium beam pipe in forward tracking region
- Reworked CDF run 1 Beryllium beam pipe through RICH Detector
- Conventional beam pipe sections (initial pipe provided by WBS 2.0)

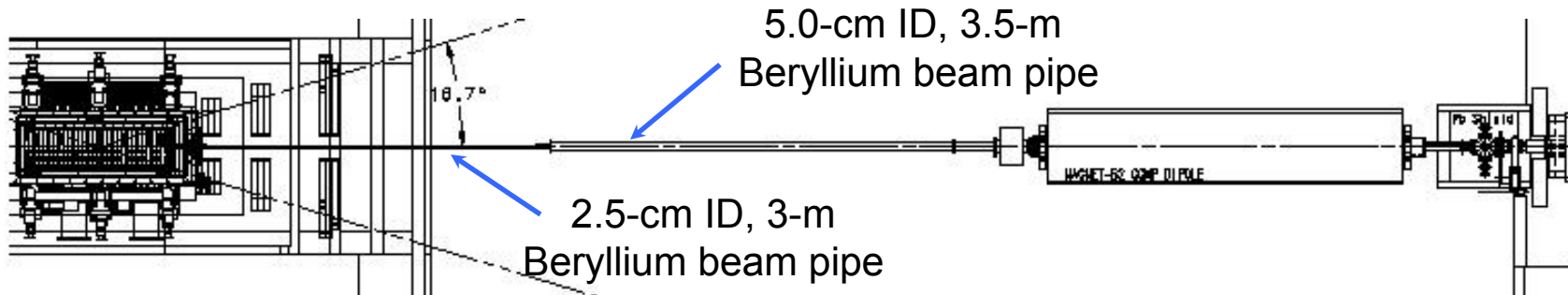
## Cost Summary

Total → 303K\$ const. + 50K\$ cont. (17%)

- 76K\$ - design
- 202K\$ - procurement
- 25K\$ - assemble & test

## Schedule Summary

- Parts acquisition delayed to match funding profile
- Critical Path: development of low mass flanges



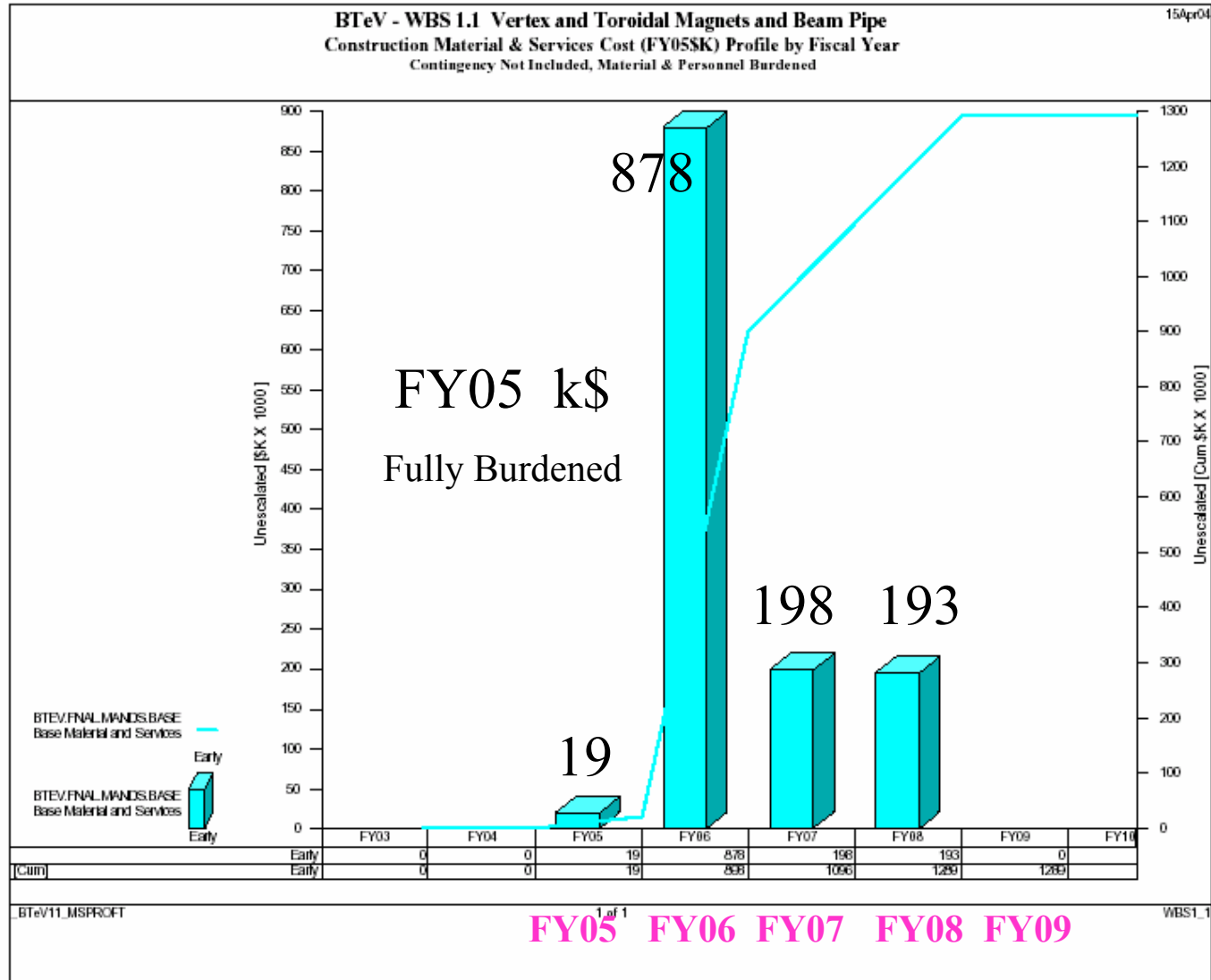
Activity ID	Activity Name	Base Cost (\$)	Material Contingency (%)	Labor Contingency (%)	Total FY05	Total FY06	Total FY07	Total FY08	Total FY09	Total FY05-09
<a href="#">1.1.1</a>	Vertex Magnet	581,284	26	24	101,871	627,733	0	0	0	729,604
<a href="#">1.1.2</a>	Muon Toroids	831,102	29	23	57,019	728,584	277,383	0	0	1,062,986
<a href="#">1.1.3</a>	Beam Pipes	302,757	11	26	0	0	112,335	240,390	0	352,725
<a href="#">1.1.4</a>	Magnet & Beampipe Software	0	0	0	0	0	0	0	0	0
<a href="#">1.1.5</a>	Integration & Testing	0	0	0	0	0	0	0	0	0
<a href="#">1.1.6</a>	Vertex & Toroidal Magnets and Beam Pipe Task Management	67,158	25	25	31,073	31,568	19,079	2,227	0	83,947
<b>1.1</b>	<b>Subproject 1.1</b>	<b>1,782,301</b>	<b>25</b>	<b>24</b>	<b>189,962</b>	<b>1,387,884</b>	<b>408,798</b>	<b>242,617</b>	<b>0</b>	<b>2,229,262</b>

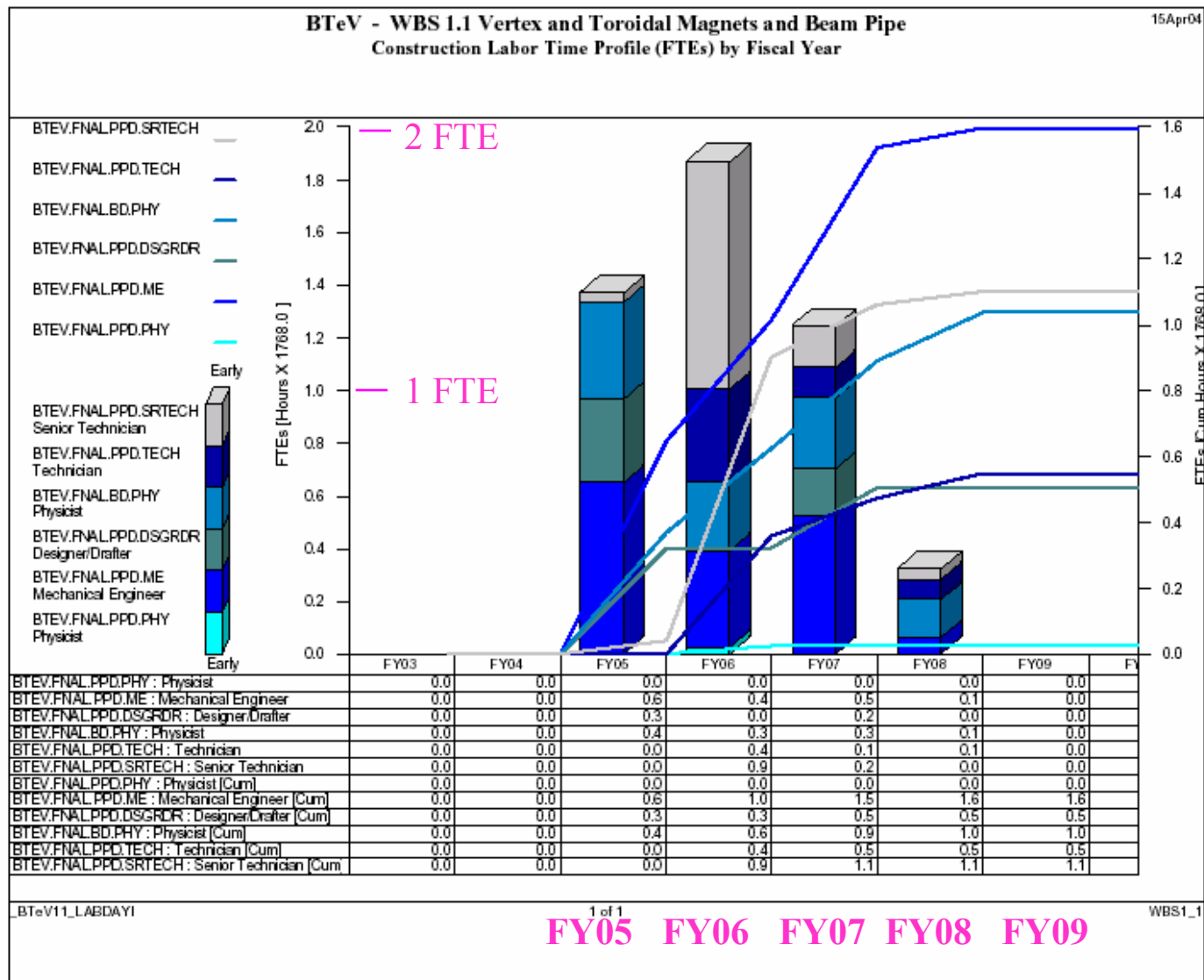
**\$1,782,301**

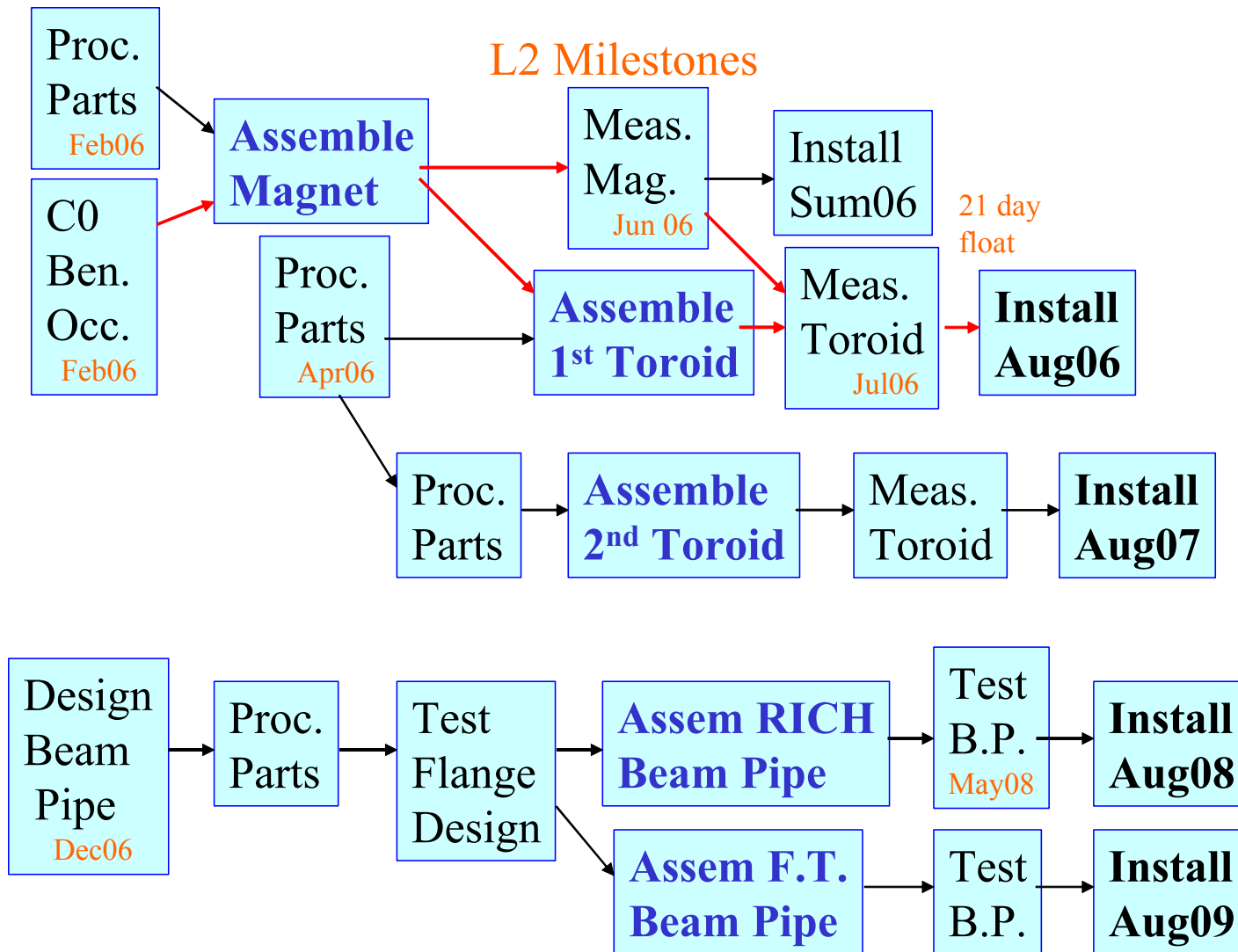
**25 %**

**24 %**

# M&S Obligation Profile by Fiscal Year WBS 1.1







<b>Milestone</b>	<b>Date</b>
<b>Vertex Magnet parts complete</b>	<b>Feb-06</b>
<b>Vertex magnet ready for installation</b>	<b>Jun-06</b>
<b>Toroid parts acquisition complete</b>	<b>Apr-06</b>
<b>1st toroid ready for installation</b>	<b>Jul-06</b>
<b>Beam pipe design approved</b>	<b>Dec-06</b>
<b>RICH Beam pipe ready for installation</b>	<b>May-08</b>

- Vertex Magnet Ready (TF = 21 days)
  - The vertex magnet needs to be ready early so the 1st toroid can be assembled.
- 1st Toroid ready (TF = 21 days)
  - The installation of the 1st toroid could be delayed to a short shutdown in FY07 if necessary with little overall schedule impact.
- RICH Beam Pipe ready (TF = 90 days)
  - The funding for the beam pipe is not available until FY07. If delayed the beam pipe could be installed after the RICH tank is installed.

Risk Event	Response/mitigation strategy
Damage to Vertex Magnet Coils	Coils have been successfully repaired in past
Low-mass Beam Pipe Flanges are hard to produce	Heavier flanges can be used until flange development program is successful
Beam pipe vacuum leaks	Plan for beam pipe completion well ahead of installation date.

The following are the high-level requirements for the installation, integration, and commissioning of the BTeV spectrometer that are necessary for BTeV to achieve its physics goals.

The primary goal of the installation coordination is to take maximal advantage of Tevatron down periods throughout the duration of the project in order to install the complete BTeV detector in the C0 collision hall.

The primary goal of the integration task is to minimize the interferences between the various detector components while simultaneously minimizing the amount of material in the aperture of the spectrometer.

The primary goal of the commissioning coordination is to ensure that the spectrometer can be completely commissioned in a minimal amount of time.

- Installation and integration planning
  - Overall drawings, numbering systems, cable and rack plans
  - Procedures, operations documents and ES&H guidance
- Infrastructure and common procurement
  - Design, parts acquisition and installation of common use infrastructure
    - Electronics cooling water, gas sources, racks
  - Procurement coordination of HV & LV power supplies and cables
- Detector Transportation, Assembly and Installation
  - Placing detector and installing support systems
  - Cable and rack installation
  - Survey and alignment
- Stand-alone and Multi-system interconnections and testing
  - Complete connections and test systems
  - Interconnect detectors, DAQ and Trigger and test
- Coordination with WBS 2.0 and WBS 3.0

Item	WBS 3.0	WBS 1.10	WBS 2.0
Power	Shielded transformers for collision hall and counting rooms. Breaker panels in each major building section.	Power distribution to racks and detectors	
Backup power generator & UPS	Complete responsibility	None	
LCW		Connections including bus from header to Magnets & PS	Headers with valves along walls in Collision and Assembly hall
Chilled Water	Complete responsibility	None	
Third floor counting room cooling	Complete responsibility	None	
First floor and collision hall rack cooling	Chilled water for ECW. Headers under 1 <sup>st</sup> floor of counting room	Electronics cooling water system and distribution manifold	
Fire detection system	Room monitors in Collision, Assembly halls and Counting rooms	Smoke detection as part of rack protection	
Counting Room Ground Plane	Complete responsibility	None	
Collision Hall Ground Plane	None	Complete responsibility	
Large Shield Door Operation		2006-2009 shutdowns	2005 shutdown only
ODH Barrier at Tunnel/Hall		None	Complete responsibility
Gate Valves & Instrumentation		Instrumentation and pumps	Gate Valve at low Beta Quad
Beam Pipe		Final pipes	4" pipe at 2005 shutdown

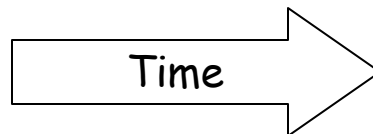
**1.10.1** System Installation, Integration, Testing and Commissioning Planning

**1.10.2** Infrastructure Development and/or Procurement, Installation and Testing at C0

**1.10.3** Component and System Transportation to and Assembly, Installation and Infrastructure Connections at C0

**1.10.4** Stand-Alone Subsystem Interconnections and Integration and Testing at C0

**1.10.5** Multiple Subsystem Interconnections and Integration and Testing



**1.10.6** System Integration and Testing

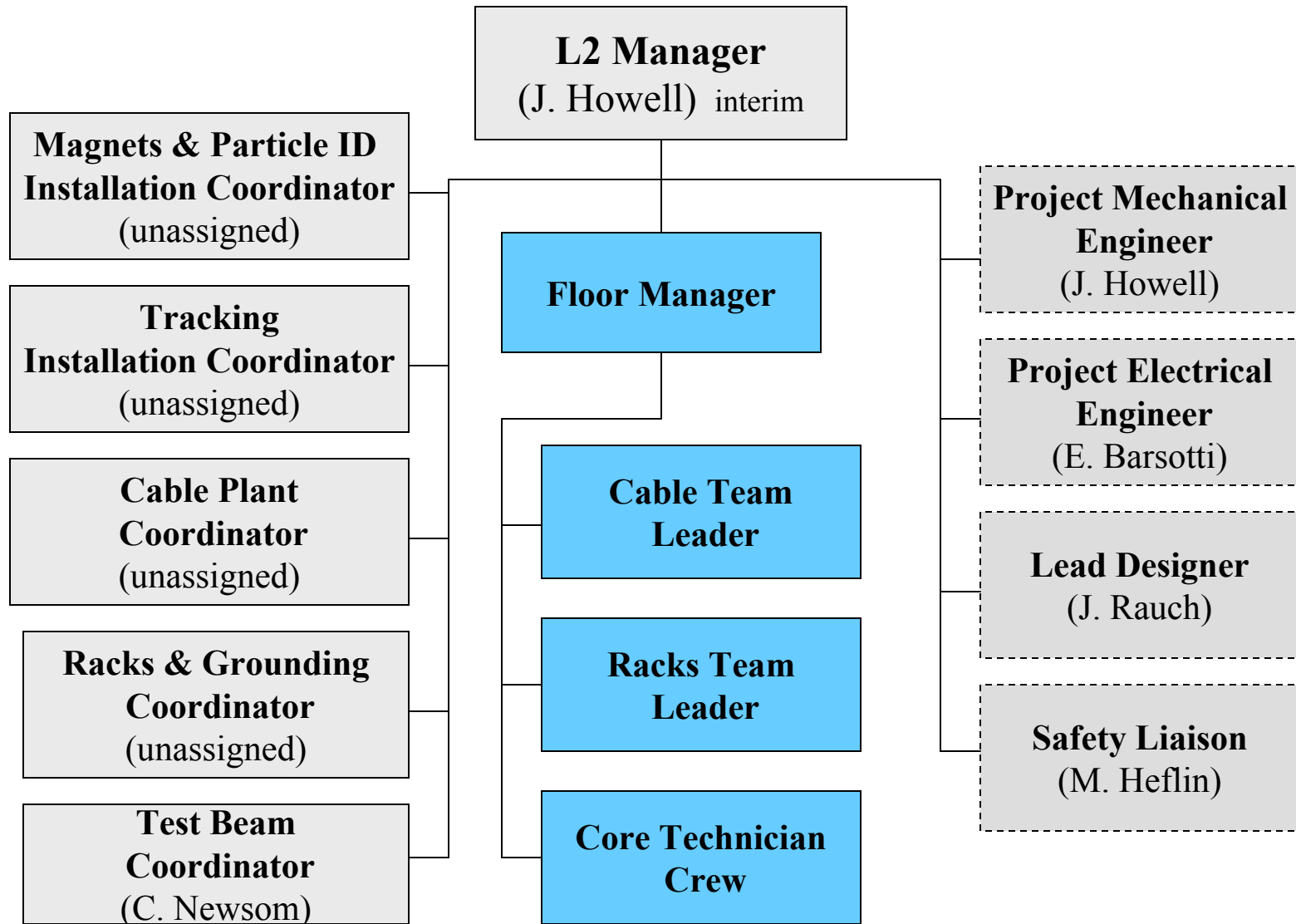
**1.10.7** System Installation, Integration and Commissioning Subproject Management

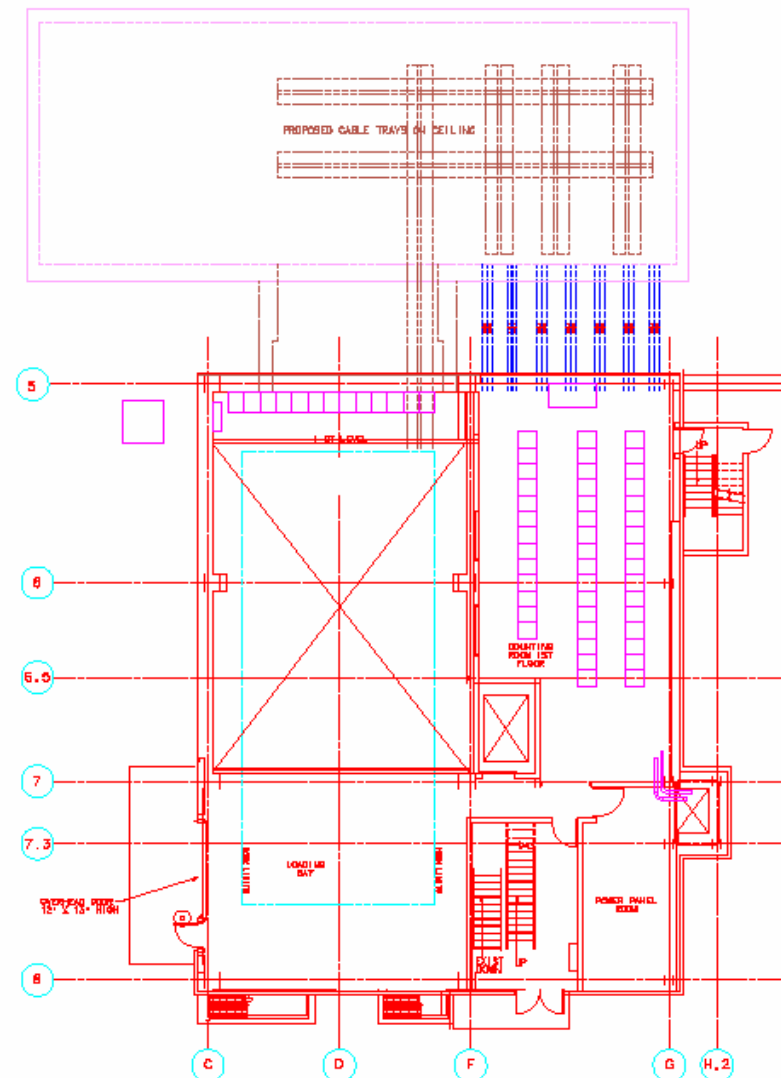
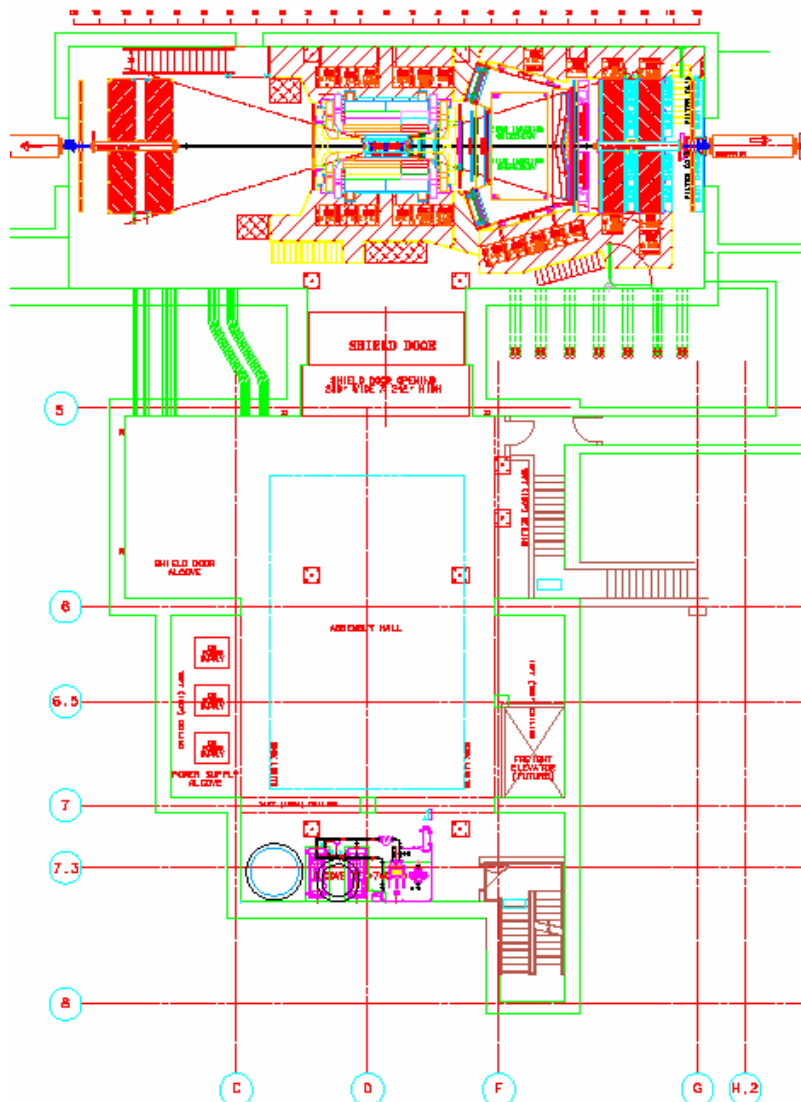
FY2006

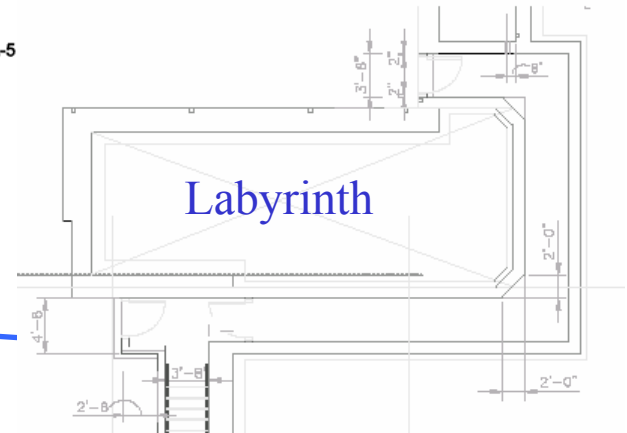
FY2007

FY2008

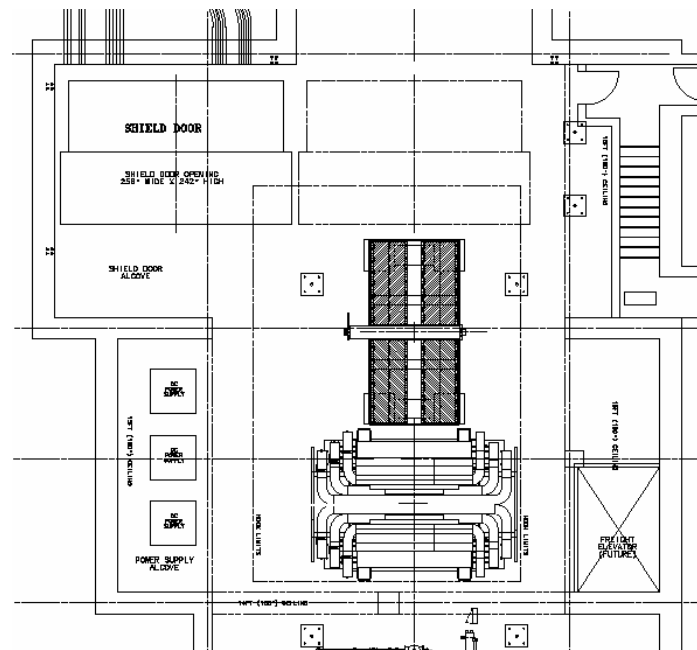
FY2009



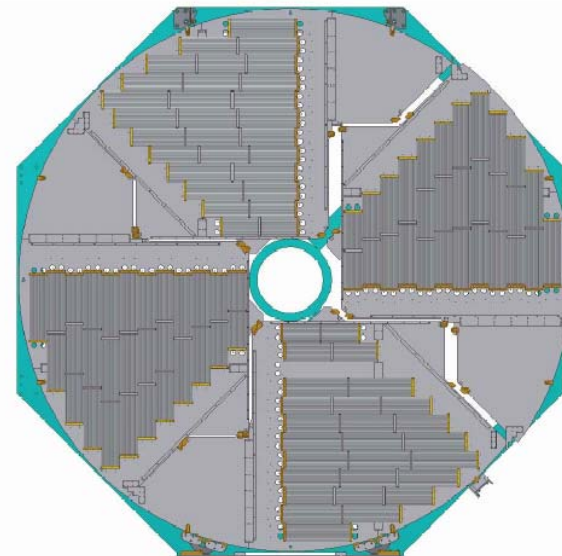




- Characteristics
  - Massive (~400 Tons each)
  - Only 2 fit in the assembly hall at one time
  - The foundation for other detectors
- Schedule Notes
  - Need access to C0 building for assembly
  - Need LCW and power for testing
    - LCW from WBS 2.0
    - Power from C0 outfitting Phase 1
  - Need to move them into the collision hall to clear assembly hall for later detectors
    - South Toroid and Vertex Magnet in 2006 shutdown
    - North Toroid in 2007 shutdown



- Characteristics
  - Multi-part (10K Crystals, 24 Muon Wheels)
  - Generally independent of other detectors
  - Component availability phased over 2+ years
- ECAL Schedule Notes
  - Support structure assembled in collision hall along with RICH after 2nd Toroid is installed
  - Partially filled support structure installed in 2008 shutdown
  - Crystal availability is spread from late 2007 until 2009
- Muon Schedule Notes
  - Requires Toroid Magnet
  - Some Muon Wheels will be installed on North Toroid before 2007 shutdown
  - The balance installed in the collision hall as “knitted” plate segments on rollers
  - Wheel availability is spread from 2006 until 2008

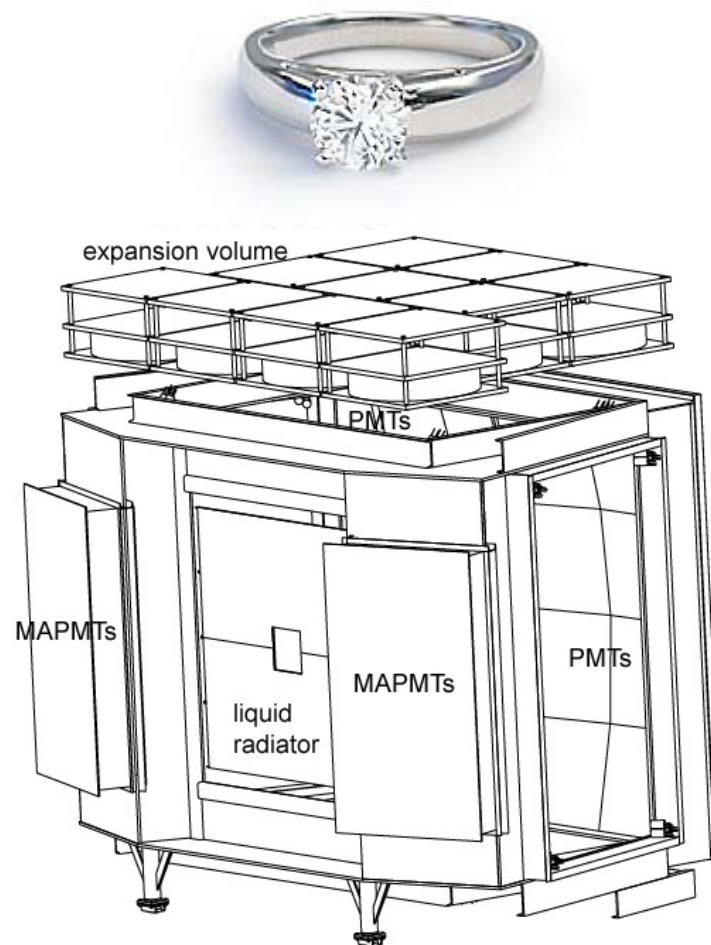


## ■ Characteristics

- Large (does not fit past Vertex Magnet with MAPMT array's in place)
- Many features (Mirrors, liquid radiator, MAPMT's, PMT's)
- Be beam tube section passes through RICH

## ■ Schedule Notes

- RICH Tank assembly must take place in C0 Assembly hall
- RICH Tank with mirrors are installed in 2008 shutdown
- Several mirror installation/alignment scenarios are possible
- Final RICH components available in early 2009



- Characteristics

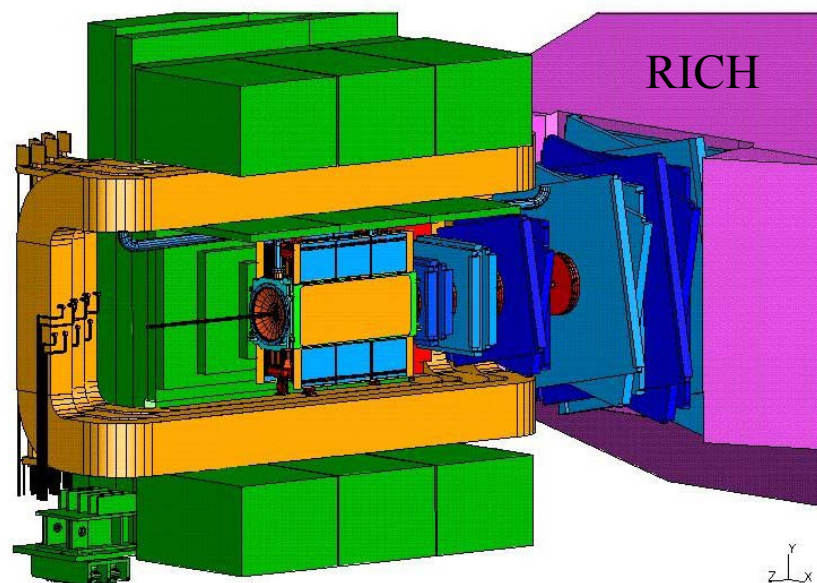
- Light to moderate weight  
(few to 1000 kg)
- Very delicate
- Straws and Strips split to fit  
around beam pipe
- Congested Installation
- ~8K cables plus cooling & dry  
purge lines

- Installation Sequence

- 1st Pixel detector
- 2nd Forward tracking beam pipe
- 3rd Straw and Strips (6 Stations)

- Schedule Notes

- Pixel detector and straw stations  
available in early 2009



Half of vertex magnet removed

	Collision Hall	Assembly Hall	Counting Rooms	Tev. Tunnel
Summer 2005 Shutdown	Remove Magnets Install LCW lines	Install LCW lines		Reconfigure for C0 straight
Fall 05 – Summer 06		Install power for magnet Assemble and test Vertex Mag. & 1 <sup>st</sup> Toroid	Install structural, floors and block wall	<div>color code</div> <div>WBS 3.0</div> <div>WBS 2.0</div> <div>WBS 1.10</div>
Summer 2006 Shutdown	Install power for racks Install Vertex Mag. & 1 <sup>st</sup> Toroid			
Fall 06 – Summer 07		Assemble 2 <sup>nd</sup> Toroid Begin RICH assembly	Finish counting rooms Finish building power	
Summer 2007 Shutdown	Complete & commission HVAC Install 2 <sup>nd</sup> Toroid Install partial Muon			Begin installing low Beta Quad buswork
Fall 07 – Summer 08		Assemble ECAL structure Continue RICH assembly	Install racks	
Summer 2008 Shutdown	Install partially filled ECAL Install RICH with Mirrors			Remove Q1 magnets and P spool Continue buswork
Fall 08 – Spring 09		Stage Pixel & Tracking	Install Trigger & DAQ	
Summer 2009 Shutdown	Install Pixel & Tracking Finish: RICH, ECAL, Muon		Finish Trigger & DAQ	Install new IR components

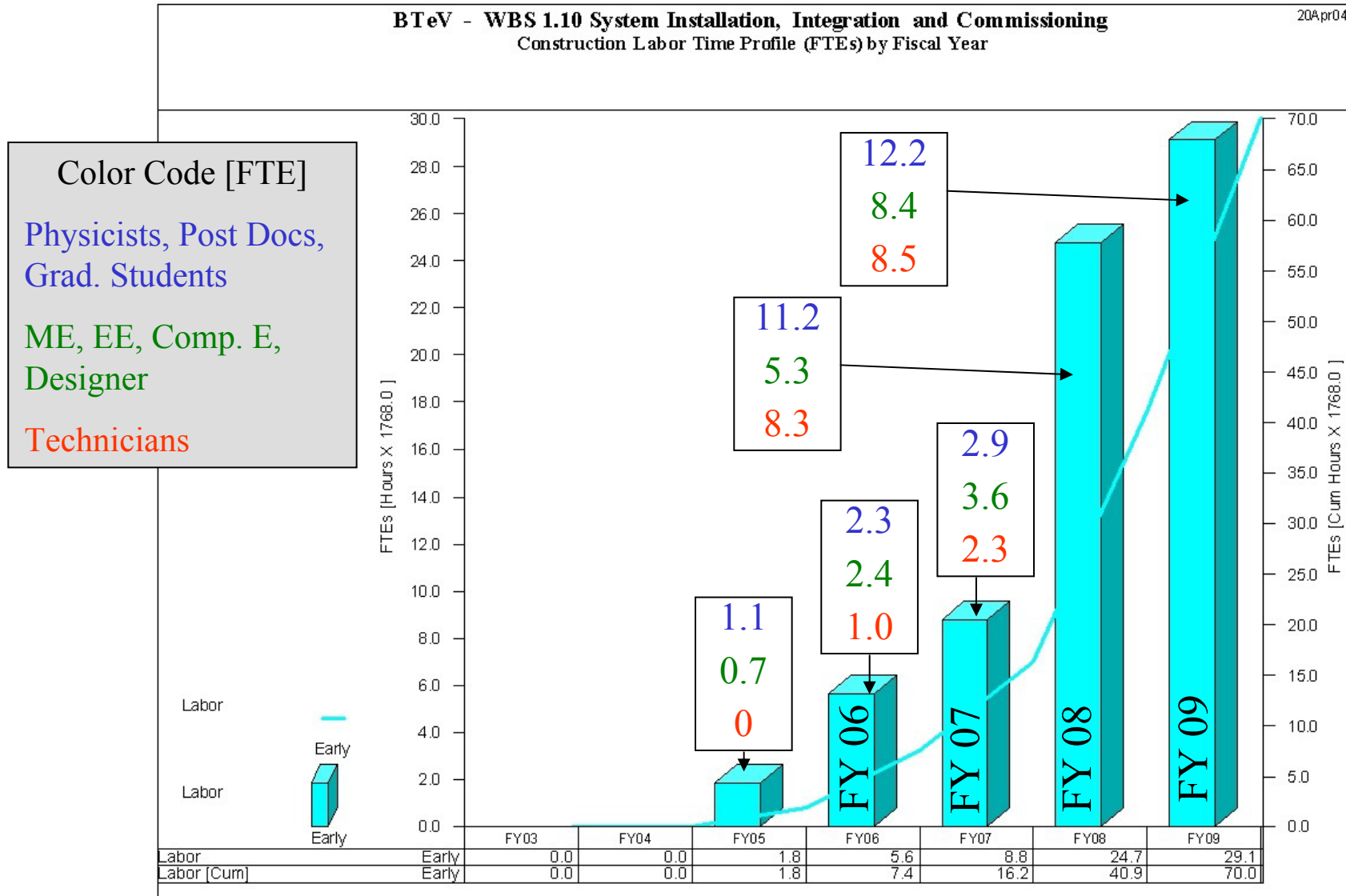
Activity ID	Activity Name	Base Cost (\$)	Material Contingency(%)	Labor Contingency (%)	Total FY05	Total FY06	Total FY07	Total FY08	Total FY09	Total FY05-09
<a href="#">1.10.1</a>	Installation Integration Testing and Commission Planning	433,745	0	35	0	121,765	142,288	296,810	26,191	587,054
<a href="#">1.10.2</a>	Infrastructure Development Procurement InstallTest at C0	2,907,607	23	34	8,381	590,634	1,296,282	1,750,432	51,425	3,697,153
<a href="#">1.10.3</a>	Component and Syst Transport Assembly Install and Connect	1,769,422	40	69	0	126,662	308,421	1,356,530	1,151,106	2,942,719
<a href="#">1.10.4</a>	StandAlone Subsys Interconnection Integrat Testing at C0	652,399	0	100	0	0	1,618	290,821	1,012,359	1,304,798
<a href="#">1.10.5</a>	Multiple Subsys Interconnect and Int Testing at C0	589,712	0	100	0	0	0	0	1,150,423	1,150,423
<a href="#">1.10.6</a>	System Integration and Testing	23,200	0	0	0	0	0	0	23,200	23,200
<a href="#">1.10.7</a>	System Install Integrate Commission Subproject Management	490,372	0	20	127,407	129,955	170,601	150,725	27,000	578,687
<b>1.1</b>	<b>Subproject 1.10</b>	<b>6,866,456</b>	<b>23</b>	<b>61</b>	<b>135,788</b>	<b>969,015</b>	<b>1,919,210</b>	<b>3,845,317</b>	<b>3,414,704</b>	<b>10,284,034</b>

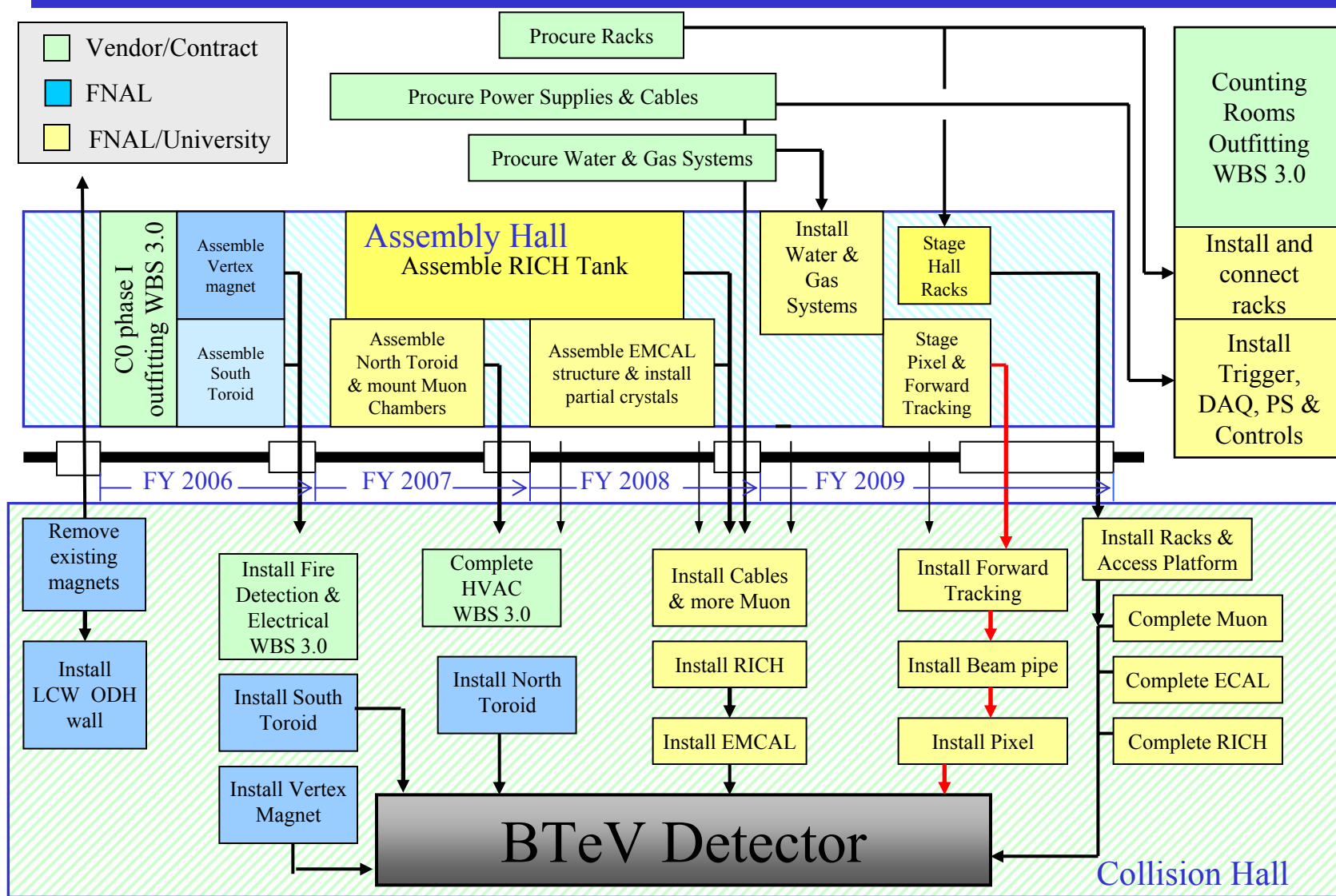
**\$6,866,456**

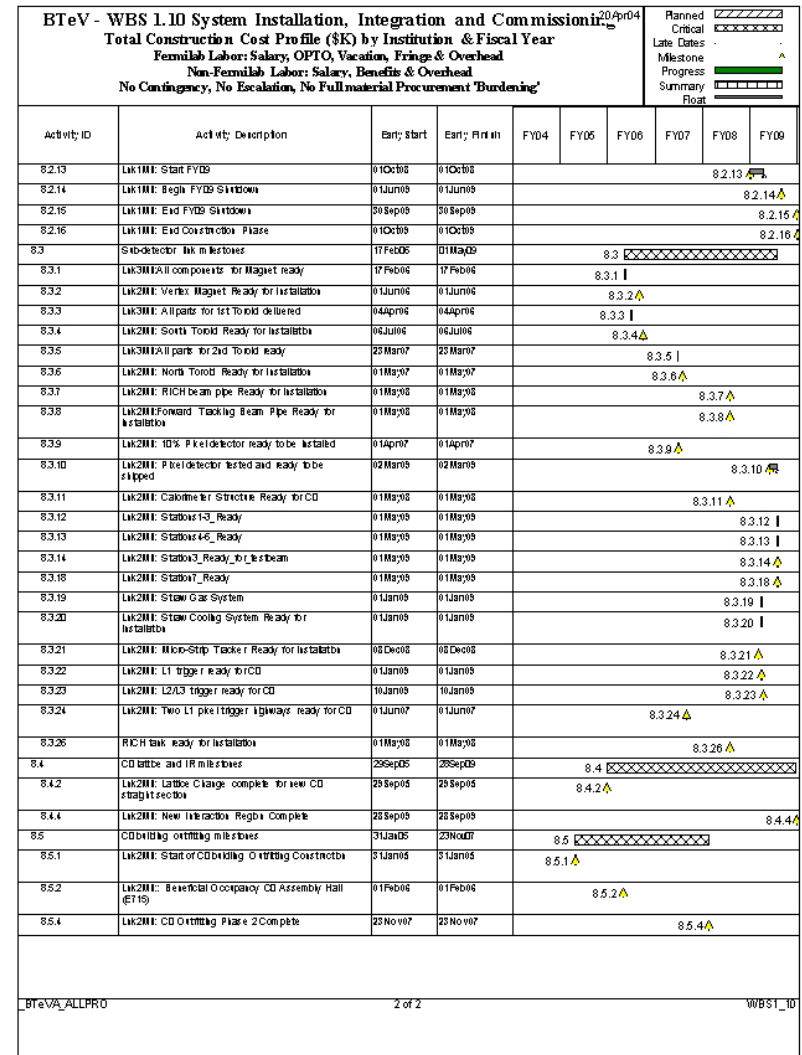
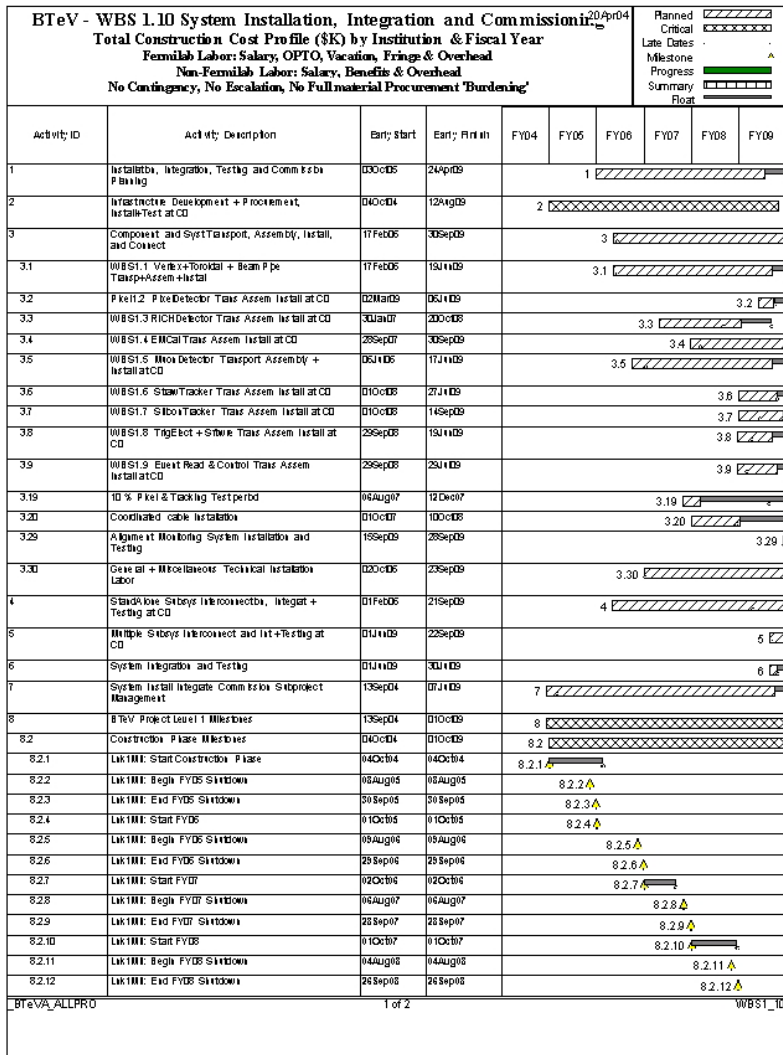
**23 %**

**61 %**









<b>Milestone</b>	<b>Date</b>
<b>PO Placed for Production of HV Power supplies</b>	<b>Oct-07</b>
<b>High Voltage Power Supplies Delivery Complete</b>	<b>Jan-09</b>
<b>Vertex Magnet, South Toroid installed</b>	<b>Sept-06</b>
<b>North Toroid Installed</b>	<b>Aug-07</b>
<b>EMCAL Support structure (partially loaded) installed</b>	<b>Aug-08</b>
<b>Rich Tank Installed</b>	<b>Sept-08</b>
<b>Trigger, Data Acquisition System installed</b>	<b>Aug-09</b>
<b>All remaining detectors installed</b>	<b>Jul-09</b>

- The smallest float is for the installation and integration of the **pixel detector**. The forward tracking and RICH MAPMT arrays follow in sequence and have similar floats but their installations have options for staged installation that the pixel detector does not. Once the pixel detector and the forward tracking beam pipe are installed, vacuum could be re-established throughout the entire detector beam pipe. The forward tracking and other detectors could be completed in stages during future access.
- The next smallest float is for the installation of the large detectors. They are all installed in 8 week shutdowns. The essential function of these installations is to clear the assembly hall for the assembly of the following detectors. Any large detector can be placed in the collision hall during a shorter shutdown and thus options exist to recover from a schedule slip or take advantage to install detectors early.
- The final consideration in maximizing schedule float is to perform as much work as possible prior to the final shutdown.

Risks	Response/mitigation strategy
A particular detector is late	The early large detectors have flexible schedules and workarounds can be developed for some schedule slips. Focus will be on maintaining the schedule of the pixel detector
Grounding scheme may not work as anticipated	As each electronic system is commissioned, its noise level will be carefully checked against system requirements. If any system has excess noise, all further installation will stop until the noise source has been identified and a mitigation plan has been formulated. Use the early installation stages to study potential noise issues.
Shutdown schedule changes	The early large detectors can be installed in the collision hall in shorter shutdowns. Even if they are not fully connected the essential function of clearing the assembly hall for following detectors can be met. The installation plan can take advantage of shorter shutdowns to recover from shutdown slips or install detectors early.

WBS 1.1

- Vertex and Toroid magnets are conventional and their costs are well understood
- Need to build early to clear the hall for following detectors
- RICH Beam pipe needed 2008, Forward Tracking BP needed 2009
- Base \$1.8M and 25 % contingency for \$2.2M total

WBS 1.10

- Extensive coordination has taken place between Detector Installation, Building Outfitting and C0 IR on Schedule and Infrastructure
- WBS dictionary and BOE are in place
- Detailed planning activities underway
- Major detector installation steps and schedule have been established
- Base \$6.8M and 50 % contingency for \$10.3M total

Additional information will be available in the breakout sessions

WBS 1.1

- Overview – Chuck Brown

WBS 1.10

- Overview – Joe Howell
- Survey and alignment – Herman Cease
- Racks and grounding – John Anderson
- Cable plant – Linda Bagby